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US Army Corps
of Engineers

Review of Model Plans for the John F. Baldwin Ship Channel Project

by The Committee on Tidal Hydraulics

Prepared for U.S. Army Engineer District, San Francisco

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Final report

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Contents

Preface

The U.S. Army Corps of Engineers Committee on Tidal Hydraulics held its 104th meeting at the U.S. Army Engineer District, San Francisco, on 18-20 April 1995 at the invitation of LTC Michael Walsh, Commander. The principal purpose of the meeting was to review phyysical and numerical modeling of the proposed John F. Baldwin navigation channel Phase III improvements and provide recommendations on further model studies.

The Committee on Tidal Hydraulics prepared this report to answer questions posed by the District. Primary authors were Dr. Ray B. Krone, consultant to the Committee; Edward A. Reindl, Galveston District; and Virginia R. Pankow, Water Resources Support Center. District liaison was provided by Mr. William C. Angeloni. Waterways Experiment Station liaison was provided by Mr. William H. McAnally.

Mr. Frank A. Herrmann, Jr., was Chairman of the Committee on Tidal Hydraulics, and Mr. Samuel B. Powell was Headquarters, U.S. Army Corps of Engineers, Liaison.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
cubic feet	0.2831685	cubic meters
feet	0.3048	meters

1 Introduction

The John F. Baldwin (J.F.B.), Phase III, navigation project in the upper San Francisco Bay system includes deepening the West Richmond Channel, the Pinole Shoal Channel, the Carquinez Strait Channel, and the Suisun Bay Channel to Avon near Point Edith. Locations of these channels are shown in Figure 1 (1). The project includes deepening from the presently maintained 37 ft MLLW depth to 45 ft and maintaining a 520 ft channel width. The Stockton Project, to be considered later, would include deepening the present channel from 35 ft to 40 or 45 ft between the upstream limit of J.F.B. Phase III and the Port of Stockton.

The Delta region, shown as a network of channels on the right side of Figure 1, is an agriculturally productive region that relies on fresh water in the channels for irrigation of the islands. The Delta is also a conduit for water transfer from the Sacramento River to U.S. Bureau of Reclamation Central Valley Project and California State Water Project pumps at the southern end of the Delta and to the Contra Costa Water District intake south of Antioch. The uses of fresh waters from Delta channels would be impaired by increases in water salinity.

The fishery in the Bay-Delta system has declined to very low levels as fresh water export from the Delta increased and outflows from the Delta to the bays have consequently decreased. Negotiations between the federal and state water agencies and the federal agencies concerned with the fishery have resulted in an agreement (15 December, 1994) prescribing the salinities downstream from Chipps Island, and thereby the amount of fresh water outflow, for various amounts of freshwater runoff (2)(3). However, the agreement is limited to three years and may be subject to revision within that time.

Concern for both water quality in the Delta and the habitat value of the estuary led the San Francisco District to extensive studies of the effect of the J.F.B. Phase III channel deepening on the upstream intrusion of sea salts. These studies included the use of the San Francisco District's hydraulic Bay Model at Sausalito and numerical models at the Hydraulics Laboratory, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi. Results of these studies are presented in references (1) and (3). Lieutenant Colonel Michael J. Walsh, Commander of the San Francisco

District, invited the Committee on Tidal Hydraulics to review these studies. His invitation included:

> "..Our goal is to have the committee review physical and numerical tests which have been performed to address salinity changes which might occur from channel deepening in San Pablo Bay, offer its advice on what the future might hold for the physical model, and consider the method for determining salinity changes/magnitude if the Stockton Ship Channel is deepened three feet."

These charges to the Committee were elaborated by Mr. William Angeloni, Chief of the Planning/Engineering Division, San Francisco District. His elaborations are presented in the appropriate sections below as "Charges."

The Committee met at the Bay Model in Sausalito 18 to 21 April, 1995, to respond to these charges. Presentations of the physical and numerical model study results were made by the modelers and were discussed during the meeting. This report is based on information provided at that meeting and has been reviewed by the members of the Committee.

2 The Physical Hydraulic Model Tests

The Bay Model at Sausalito was constructed in 1957 to evaluate various plans for modifying the Bay system: the "Reber Plan," a barrier at Dillon Point, and others, as well as means to reduce sedimentation rates in Mare Island Strait and evaluation of the extent of pollution that might be anticipated from collision of nuclear powered ships. Private projects, such as design of small craft harbors and tanker wharfs and previous salinity studies, have also used the model. It was extended to include the Delta in 1969, and was used to evaluate impacts of the proposed Peripheral Canal, a facility to convey Sacramento River water around the Delta to the export pumps. The model has since been used to evaluate various J.F.B. plans.

Scales of the model are 1:1000 horizontally and 1:100 vertically. These scales provide feasible horizontal size to the model and usable vertical dimensions for measurement of tides, currents, and salinities. The scale distortion is compensated by vertical copper strips that provide friction and mixing throughout the model water depth. This arrangement has been widely used by estuarial modelers. The model scales produce a tidal cycle period of 14.9 minutes -- about 1/100th of the time of a tidal cycle in the Bay.

The seaward boundary conditions of the model to date have been salt water (NaCl) at 33 ppt and a 19-year mean tide. These conditions are held precisely. The mean tide is repeated: there is no spring/neap or annual cycle. Landward boundary conditions have been provided by appropriate flows of tap water.

Charge 1

Is the physical model still a viable tool and worth keeping operational given recent developments in numerical modeling and the fact that the Corps has only the John F. Baldwin Project, and possibly the Stockton Project, which might need its services in near term? Could this facility be of assistance to the State of California as they work to develop a comprehensive water management plan to meet the new Bay-Delta Standards?

For the reasons given below, the Committee on Tidal Hydraulics considers the physical model to be a viable tool for predicting the effects of the John F. Baldwin Project, and it could be of assistance to the State of California's studies as well. Its usefulness to the Stockton project depends on when the study takes place and how rapidly the numerical models have matured in the intervening time. This assessment of the physical model's usefulness is predicated on the model improvements recommended below.

Physical hydraulic modeling is an established technology that has evolved over more than 60 years. The Bay Model provides a three-dimensional representation of the complex currents and tides throughout the Bay-Delta system at a time scale that facilitates quantitative simulation of an entire year in a few 24-hour days.

The model provides a facility for demonstrating complex processes in the Bay that can easily be understood by members of regulatory agencies and the general public, and the Bay Model is widely known in the San Francisco Bay region. It should be a valuable tool for evaluating Delta outflow -- salinity relations. There are, however, limitations to the model as it stands, as described below.

The TABS-MD/RMA10 numerical model applied to the system by the USAE Waterways Experiment Station (3) solves the momentum, continuity, and advection-dispersion equations as constrained by the configuration of the system and the tide, salinity, fresh water flows, and wind boundary conditions. Graphical presentations of data output enable visualization of the simulated hydraulic and transport processes. The several advantages to the model, vis a vis the hydraulic model, include explicit simulation of the effects of wind on the system, easy modification of the configuration and boundary conditions for prediction of alternate conditions, the provision of detailed hydraulic and salinity outputs, and the provision of currents, densities, and mixing parameters needed for sediment transport and water quality models. A disadvantage of the numerical models at present is the lower time scale: 1:8. Advancing computer technology promises to improve this time scale.

Additional responses to Charge 1, made after consideration of responses to subsequent charges, are included in Conclusions and Recommendations.

Charge 2

A number of tests have been run for the J.F.B. Project over the years to estimate salinity impacts upstream of the Project. An interagency meeting was held in January, 1995, to discuss the results of the most recent test. This group, as past groups have, suggested that a varying spring/neap condition should be run in the physical model. This has not been done in the past because the HP 1000 made this a very difficult thing to do. Recent conversion to PC control will now make this a simpler modification. Is it

still a desirable thing to do, or would simply running repetitive spring [and] neap [tides] and measuring the relative difference against the 19-year repetitive [mean][1] tide be just as meaningful?

Comparison of modeled salinities using a repeated mean tide and prototype salinities at Pittsburg is shown by Figure 25 from Reference (1). This figure shows that the spring/neap cycle causes significant variations in the maximum salinities that occur during a tidal cycle (as much a 100% at this location). The water projects are managed on a tidal basis and changes of salinity during the spring/neap cycle may become more important to water transfer operations as restrictions on water diversion increase. Further, the maximum salinities during the spring/neap cycle may impact the quality of water in Delta channels.

The averaged model salinities plotted in Figure 25 also have a smaller maximum-minimum range than have the prototype salinity variations. This difference can be due to differences of vertical mixing by a repeated mean tide and those produced by a spring/neap cycle. Similar effects can be expected at lower salinities upstream. It can be concluded that facilities that provide a variable tide would significantly enhance the accuracy of model predictions and would make model tests more useful for water agency operation studies.

A repeated spring/neap tide cycle would be a step toward a real prototype boundary condition and may be appropriate during model adjustment. However, a runup using recorded or predicted tides prior to an event of particular interest to regulatory agencies may be required to meet their concerns.

Concerns that lead to the recommendations for a variable tide include concern for the effect of antecedent tides on mixing and longitudinal transport, as well as for the range of salinities. Repeated spring and repeated neap tides would not provide convincing predictions of salinity intrusion impacts of the J.F.B. project.

Future Actions, Charge 2, Continued

Additionally, after the January, 1995 meeting, a list of proposed actions (par 13) was included as part of the minutes. We request that the Committee evaluate these proposed actions and provide input as regards their effectiveness in addressing the salinity issues for this project.

---

[1] Changes approved by W. C. Angeloni.

Paragraph 13[1] and Committee responses are:

> Proposed Actions *As a result of the 30 January 1995 conference, a follow-up meeting held 31 January 1995 with Bill McAnally and Joe Letter, and the correspondence received to date, the following actions are proposed. Many of these items are for CEWES and are summarized in their 1 February 1995 draft Scope of Work.*
>
> *a. Follow-up on any success stories with the Savannah District of the Corps in correctly predicting the effect of channel deepening on salinity intrusion (action: EIS coordinator, Peter LaCivita).*

The purpose of this action is to support the credibility of model predictions of salt intrusion. Other examples that can be described to support model predictions include model and prototype data from the Delaware estuary, James River estuary, and Charleston Harbor model studies.

> *b. Address whether the numerical and physical models successfully reproduce residual gravitational circulation and vertical mixing processes in the northern San Francisco Bay reaches of interest.*
>
> (1) *For the TABS Mesh-J model, additional data analyses and displays will be prepared (i.e., velocity and salinity profiles and "stick diagrams" of residual current) to demonstrate the degree to which the model reproduces the vertical mixing and residual gravitational circulation observed (Jon Bureau, USGS data) in the prototype estuary (action: CEWES with MIPR from PM, Geoff Chatfield).*
>
> (2) *For the physical model, similar displays will be extracted from earlier model reports (flow-predominance curve for repetitive mean tide) for demonstrating reproduction of observations from the prototype estuary. Comparisons of model and prototype vertical salinity profiles would also be revisited (action: Bay Model Director, Lyn Hawkins with contract to someone).*

Both the physical and 3-dimensional numerical models simulate vertical mixing. Evaluation of the accuracy of the simulations should be a part of model verification: current profiles and longitudinal and vertical salinity profiles measured in the prototype in the mixing zone should be simulated by the models. The actions planned should display mixing processes, and comparison with prototype currents and salinities, indicated in (2), should lead to verification.

> *c. Resolve the differences between the physical and numerical model results.*

[1] W. C. Angeloni, San Francisco District, letter dated 7 February 1995, Subject: January 30, 1995 Physical Model Data Test Review Conference.

(1) *Using the same 4400 cfs net Delta outflow and the 7-day abbreviated simulation period, sensitivity tests will be conducted in the numerical model to examine the relative contribution to salinity transport and changes from numerical model runup/quasi-equilibrium, neap-spring tidal variability vs repetitive mean tide, subtle bathymetric differences, and other contributing factors. Analyses of these sensitivity tests will be used to define the probable causes of model differences and to design a confirmatory model test (action: CEWES with MIPR from PM, Geoff Chatfield).*

(2) *Potential bathymetric differences between the numerical and physical model around the Bull's Head fillet will be double checked in the physical model as well (action: Bay Model Director, Lyn Hawkins).*

(3) *The TABS Mesh-J model will be run under a 4400 cfs net Delta outflow condition for a complete experiment (28 days) to confirm the sensitivity test findings (action: CEWES with MIPR from PM, Geoff Chatfield).*

(4) *Results of the confirmatory test and previous experimental results will be analyzed to determine the best estimates of JFB III-induced salinity changes. These "best estimates" are to be used in the draft EIS due out in the July/August 1995 time frame and are, therefore, required around May/June 1995 at the latest for incorporation into the DEIS. The DEIS will also identify further testing proposed as well as a pre- and post-construction monitoring plan (lead action: EIS coordinator, Peter LaCivita with input from CEWES and others).*

These efforts should illuminate causes of differences in salinities shown by the physical and numerical models and lead to consistent model results. It is essential that the models have the same boundary conditions, and accurate comparison with prototype data requires that prototype boundary conditions be used, including a variable tide. Department of Water Resources prototype data show that salinities in the Delta are affected by changes in inflows and diversions two months or more after the change, particularly during summer flow conditions. Since the system is dynamic, comparison of model outputs and comparison of model and prototype data should be made under comparable antecedent flow and salinity conditions. Comparison of pre- and post-project salinities should also be made with the same antecedent conditions.

d. Determine the most meaningful methods of presenting the salinity findings and any additional sensitivity tests required to make the presentation more meaningful.

(1) *The appropriate standards for salinity (in what areas under what outflow conditions, e.g., 2 ppt limit at 7100 cfs?) against which project impacts will be judged must be identified for determining any*

further testing and the best ways to present the data so that it will be useful to all regulatory agencies (action: EIS coordinator, Peter LaCivita).

Flows under the December 15, 1994 agreement are summarized in Table 1. The entries in Table 1 show ranges, however, and a sliding scale for the X2 requirement makes conditions of most concern by the resource agencies uncertain. Plans for future model tests should be made with consultation with these agencies to focus on their particular concerns.

(2) *Depending on the outcome of the sensitivity tests and confirmatory test using the TABS Mesh J model (i.e., if the results of 7-day tests are found to be meaningful), additional sensitivity testing will be designed to address the effect of different net Delta outflows (i.e., those conditions determined in d(1), revisions to the project design (e.g., using a 35-foot depth in the Avon Turning Basin instead of 45 feet), and other conditions that are identified as pertinent. This testing would be scheduled to occur prior to the final EIS (action: CEWES with MIPR from PM, Geoff Chatfield).*

e. *If the spring/neap tide effects are isolated as the sole source of the difference between the physical and numerical model results, then the physical model should be set-up with a variable tide as soon as possible to validate the numerical results, especially if the numerical results are perceived as prohibitively high by the regulatory agencies and affected parties. One possible option in the near term would be to run a repeating neap tide on the physical model as a sensitivity test of lesser tidal flows and greater residual gravitational circulation (action: Bay Model Director, Lyn Hawkins).*

As noted above, a variable tide in the physical model is needed to simulate salinity intrusion changes during the spring/neap period. A repeated neap tide will never occur, and a model test with this boundary condition would not provide information that is directly useful for approval of this project.

f. *The suggestion of Dr. Cheng's to form a Technical Advisory Committee with the full cooperation of Corps management needs to be seriously considered. Such an arrangement could lead to more extensive modeling work than that proposed here and would likely require significant use of the physical model and result in project delays and increased cost. This, however, may be well worth it and should be discussed at an upcoming meeting between the Colonel, Project Management, and the Sponsor (action: Geoff Chatfield, Arijs Rakstins, Colonel Walsh, Bill Angeloni, Tom Kendall, Roberta Goulart, CEWES, Lyn Hawkins).*

The Corps of Engineers has many employees and consultants who are highly qualified numerical and physical modelers and who are intimately familiar with the San Francisco Bay system. A committee that is composed of Corps personnel and on-going Corps consultants would focus on Corps'

but its services have been rarely used in recent years. Reviews of modeling plans by that or a similar committee can enhance the efficiency of testing programs.

In addition, the Hydraulics Laboratory, Waterways Experiment Station, has a standing Bay Model Support Group of physical model engineers and technicians that has provided practical assistance in setting up the tide controls and salinity monitors. That group can assist in implementation of a variable tide generator.

J. F. B. Phase IV, the Stockton Project, Charge 3

The Corps has been asked to study a 40 to 45 ft deep navigation channel from Avon (the upstream limit of J.F.B. III) to the Port of Stockton. Should this project be modeled to estimate upstream salinity changes using both the numerical and physical models, or will the numerical model be adequate?

The credibility of the model studies and the amount of useful information provided would be enhanced by tests using both models. PC control of tides in the physical model would facilitate simulation of an entire year's tides, and the physical model's short time scale would make the simulation of salinities throughout a year's hydrology feasible. The numerical model provides a great deal more spatial and temporal detail, and can be used to simulate critical hydrologic conditions to provide information relevant to biota (i.e., migrations) at locations of interest to the wildlife agencies. Both models should be verified against the same prototype data, and both should substantially agree in the region of interest.

There are several water quality problems, in addition to salinity, in the Stockton Ship Channel and neighboring Delta channels that can be affected by changes in water depth. Dissolved oxygen, water temperature, and algae concentrations are examples. The numerical hydraulic model can provide predicted currents and mixing parameters; inputs needed for modeling these aspects of water quality impacts of the J.F.B. project. Development of a water quality model addition to the hydraulic and salinity models would provide valuable data for the J.F.B. environmental impact analyses.

3 Conclusions and Recommendations

The San Francisco Bay physical model simulates flows and salinities in the Bay-Delta system under proposed channel alterations. The simulations are readily comprehended by both technically prepared and lay persons, including regulatory and resource agency personnel and the general public. Physical modeling is a mature technology. This model has a very short time scale, making simulations of annual hydrology, or a significant portion of annual hydrology, feasible. Providing credible prediction of salinity intrusion, however, will require installation of facilities that can provide variable tides and fresh water inflows so that boundary conditions can accurately be simulated. Verification of the model over the spring/neap tide prototype data that were obtained for the numerical model studies will also be required (i.e., some adjustment of the copper tabs may be required).

The numerical models now provide graphical presentations of simulated currents, tides, and salinities that make visualization of estuarine processes accessible to regulatory personnel. These models also have unique advantages including the incorporation of wind forcing and outputs needed by numerical water quality and sediment transport models. The numerical models are easily modified to simulate proposed estuary alterations and anticipated boundary conditions.

A most desirable course of action would include upgrading the physical model by installing variable boundary condition facilities and operating it at least through the J.F.B. project, taking advantage of the ability of this model to simulate long times. At the same time, establish the three-dimensional numerical hydraulic and salinity models and demonstrate to the regulatory and resource agencies their value in flow management. By the end of the J.F.B. project the numerical models should be widely accepted and be prepared to provide needed modeling support, and the physical model can be phased for use as a small project and public education facility.

The other regulatory agencies should be invited to participate in a two-year program for extension of the numerical models to include sediment transport and water quality models -- a full suite of Bay-Delta management support tools.

These models would provide needed information for optimizing fresh water outflows from the Delta, for managing dredged sediment disposal, for regulating waste and non-point discharges, and for planning to meet future changes in the Bay-Delta configurations, such as flooding of Delta islands, restoration of tidal marshlands, and modifications of navigation facilities. Success of this plan would require participation and support by the relevant agencies and could lead to enhanced agency cooperation.

The Proposed Actions[1] describes appropriate actions to resolve the differences between the physical and numerical models and to provide data for the final EIS with this exception: A model test using repeated neap- or repeated spring tides would not provide useful data. Both the physical and numerical models should be verified against the prototype data measured during a spring/neap cycle, including salinity and current profiles and longitudinal salinity distribution in the mixing zone.

A technical review and advisory committee could enhance the efficiency of model tests, both by reviewing model plans and examining model and relevant prototype data. A committee composed of Waterways Experiment Station personnel and members and consultants of the Committee on Tidal Hydraulics would maintain the focus of the modeling on Corps objectives. The existing Bay Model Advisory Group or a similar one can readily be activated.

Future freshwater outflows from the Delta are subject to continuing negotiation among the regulatory and resource agencies. The San Francisco District should be a party to the negotiations or be intimately informed of agency concerns regarding the J.F.B. projects so that they are met as far as possible early in the EIR/EIS process. The agencies may support Corps' modeling when it contributes to resource management capability.

[1] W. C. Angeloni, San Francisco District, letter dated 7 February 1995, Subject: January 30, 1995 Physical Model Data Test Review Conference.

References

Harms, V. W., *Salinity Intrusion from John F. Baldwin Phase III Navigation Project with 45-foot Turning Basin in Suisun Bay: Results of Physical Model Test PJB4B*, EHL Report No. 9501, Environmental Hydraulics Laboratory, University of California, Berkeley, 28 March, 1995.

Fullerton, D., *Summary and Analysis: The Principles for Agreement on Bay-Delta Standards between The State of California and The Federal Government Signed on December 15, 1994* Natural Heritage Institute, 114 Sansome St. Suite 1200, January, 1995.

U.S. Federal Register, Vol. 60, No. 15, Tuesday, January 24, 1995, Rules and Regulations, pp 4672 to 4702.

Letter, J. V., W. L. Boyt, C. J. Callegan, and A. M. Teeter, *John F. Baldwin Phase III, Three-Dimensional Numerical Model Salinity Study*, USAE Waterways Experiment Station, Vicksburg, MS, (in preparation).

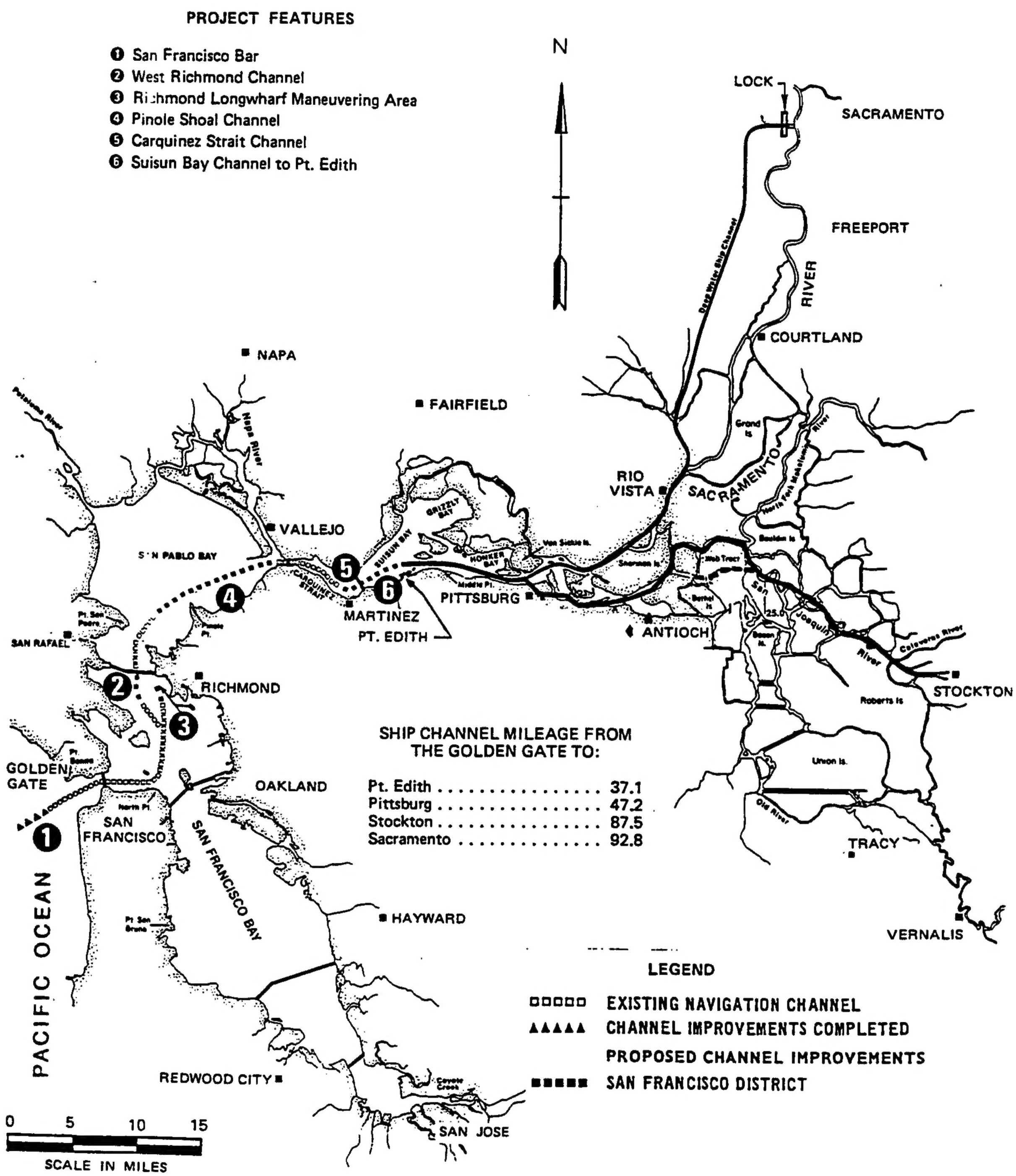
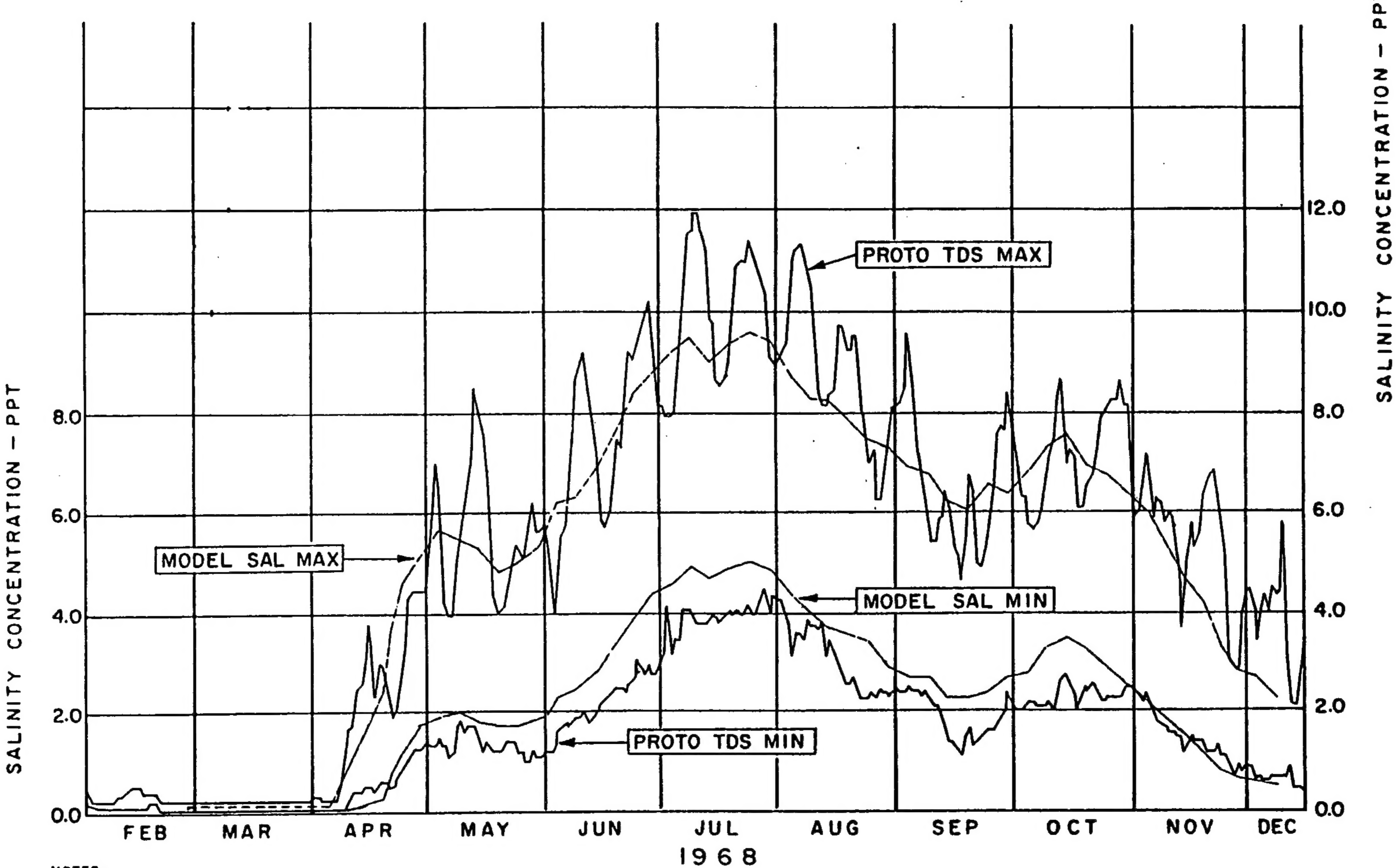


Fig. 1 Features of John F. Baldwin Navigation Project – Phase-III: Items 2,4,5,6



NOTES:

(A) TOTAL DELTA UPLAND INFLOW INCLUDES SACRAMENTO RIVER AT SACRAMENTO, SAN JOAQUIN RIVER AT VERNALIS AND MOKELUMNE AND COSUMNES RIVERS.

(B) TOTAL DEMANDS OF PUMPING PLANTS FOR CALIFORNIA AQUEDUCT, DELTA-MENDOTA CANAL AND CONTRA COSTA CANAL.

(C) TOTAL NET CHANNEL DEPLETION AT 12 POINTS DISTRIBUTED IN DELTA.

SAN FRANCISCO BAY - DELTA HYDRAULIC MODEL

DYNAMIC MODEL SALINITY VERIFICATION TEST NO. 4

MAXIMUM AND MINIMUM SALINITIES AT STATION C

SACRAMENTO RIVER AT PITTSBURG

Figure 25

Table 1
Flow and Operational Requirements
December 15, 1994 Agreement

	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN
Sacramento River Flows: Rio Vista								3	3 - 4	3.5- 4.5		
San Joaquin River Flows		1	3 - 8	1					1			
Pulse/attraction except in 2nd critical year									28 kaf			
Delta Outflow: Min flows				6	4	4- 8	3- 4	3	3- 4	3.5- 4.5	3.5- 4.5	4.5- 6
Estuarine Habitat Standard	X2 sliding scale for Chipps and Roe. Target Year 1971.5. 150 days of compliance at Confluence. Relaxations during supercritical conditions.											
Maximum Delta Inflow/ Export	45%- 35%	35%				65%						
Minimum pumping	1.5											
Adjustments to pumping standard	Allowable pumping may be adjusted downward by the Operations Group in order to limit take of endangered species or provide other environmental benefits. Allowable pumping may be adjusted upward, consistent with biological protection, to reimburse exporters for lost yield or to acquire credits.											
Cross Channel Closures	Through May 20			4 days /wk						45 days		
Old River Operations			Close					Barrier Closed				
Georgiana Slough	Acoustic Barrier									Acoustic Barrier		

All numbers are in kcfs unless otherwise specified.
When ranges are given, first number refers to critical year values, last number to wet year values

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13. ABSTRACT *(Maximum 200 words)*

The San Francisco Bay-Delta Physical Model simulates flows and salinities in the bay system. A TABS-MD numerical model of the system has been developed to assist in addressing salinity intrusion questions regarding the proposed John F. Baldwin Phase III navigation channel improvements. Questions posed by the U.S. Army Engineer District, San Francisco, have been addressed by the Committee on Tidal Hydraulics to help resolve the appropriate roles of the physical and numerical models.

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